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AUG 16 2007
PATENT & TRADEMARK OFFICE

CofC

PATENT
Attorney Docket No. BKP-008

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT(S):	Lindstrom	CONFIRMATION NO.:	7653
SERIAL NO.:	10/728,081	GROUP NO.:	3766
FILING DATE:	December 4, 2003	EXAMINER:	Gedeon, Brian T.
PATENT NO:	7,221,975	ISSUE DATE:	May 22, 2007
TITLE:	Signal Filtering Using Orthogonal Polynomials and Removal of Edge Effects		

CERTIFICATE OF FIRST CLASS MAILING UNDER 37 C.F.R. 1.8

I hereby certify that this correspondence, and any document(s) referred to as enclosed herein, is/are being deposited with the United States Postal Service as first class mail, postage prepaid, in an envelope addressed to the Attn: Certificate of Correction Branch, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on this 14th day of August, 2007.

Sarah T. Hogan

Sarah T. Hogan

ATTN: Certificate of Correction Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Certificate
AUG 20 2007
of Correction

Sir:

Submitted herewith is/are:

1. Transmittal Form (1 page);
2. Fee Transmittal (1 page);
3. Request for Certificate of Correction (5 pages);
4. Exhibit A – Specification as originally filed on December 4, 2003, and a copy of associated date-stamped return-receipt postcard (38 pages);
5. Exhibit B – Amendment and Response filed September 8, 2006, and a copy of associated date-stamped return-receipt postcard (29 pages);
6. Certificate of Correction (Form PTO/SB/44) (1 page);
7. Certificate of First Class Mailing under 37 C.F.R. 1.8 (1 page);
8. check in the amount of $100.00; and
9. return receipt postcard.

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TRANSMITTAL FORM

Application Serial Number	10/728,081
Filing Date	December 4, 2003
First Named Inventor	Lindstrom
Group Art Unit	3766
Examiner Name	Gedeon, Brian T.
Attorney Docket No.	BKP-008
Confirmation No. Patent No. Issue Date	7653 7,221,975 May 22, 2007

ENCLOSURES ***(check all that apply)***

- ☒ Fee Transmittal Form (1 pg.)
  - ☒ Check attached
  - ☐ Copy of Fee Transmittal Form
- ☐ Amendment/Response
  - ☐ Preliminary
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
  - ☐ Letter to Official Draftsperson including Drawings [Total Sheets _____]
- ☐ Petition for Extension of Time
- ☐ Information Disclosure Statement
  - ☐ Form PTO-1449
  - ☐ Copies of IDS Citations
- ☐ Certified Copy of Priority Document(s)
- ☐ Sequence Listing submission
  - ☐ Paper Copy/CD
  - ☐ Computer Readable Copy
  - ☐ Statement verifying identity of above
- ☐ Copy of Notice to File Missing Parts of Nonprovisional Application
- ☐ Formal Drawing(s)
- ☐ Request For Continued Examination (RCE) Transmittal
- ☐ Power of Attorney (Revocation of Prior Powers)
- ☐ Terminal Disclaimer
- ☐ Executed Declaration and Power of Attorney for Utility or Design Patent Application
- ☐ Small Entity Statement
- ☐ CD(s) for large table or computer program
- ☐ Amendment After Allowance
- ☒ Request for Certificate of Correction (5 pgs.)
  - ☒ Certificate of Correction (Form PTO/SB/44) (1 pg.)
- ☐ Notice of Appeal to Board of Patent Appeals and Interferences
- ☐ Appeal Brief (in triplicate)
- ☐ Status Inquiry
- ☒ Return Receipt Postcard
- ☒ Certificate of First Class Mailing under 37 C.F.R. 1.8 (1 pg.)
- ☐ Certificate of Facsimile Transmission under 37 C.F.R. 1.8
- ☒ Additional Enclosure(s) *(please identify below)*
  - ☒ Exhibit A - Specification as Originally filed on December 4, 2003, and a copy of associated date-stamped return-receipt postcard (38 pgs.)
  - ☒ Exhibit B - Amendment and Response filed September 8, 2006, and a copy of associated date-stamped return-receipt postcard (29 pgs.)

CORRESPONDENCE ADDRESS

Direct all correspondence to: Patent Administrator
Kirkpatrick & Lockhart Preston Gates Ellis LLP
State Street Financial Center
One Lincoln Street
Boston, MA 02111-2950
Tel. No.: (617) 261-3100
Fax No.: (617) 261-3175

SIGNATURE BLOCK

Respectfully submitted,

Date: August 14, 2007
Reg. No.: 58,343
Tel. No.: (617) 261-3216
Fax No.: (617) 261-3175

Karen A. Schouten

Karen A. Schouten
Attorney for the Applicant
Kirkpatrick & Lockhart Preston Gates Ellis LLP
State Street Financial Center
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Boston, MA 02111-2950

AUG 20 2007

FEE TRANSMITTAL for FY 2007

OIPE
AUG 16 2007
PATENT & TRADEMARK OFFICE

Complete if Known	
Application Serial Number	10/728,081
Filing Date	December 4, 2003
First Named Inventor	Lindstrom
Group Art Unit	3766
Examiner Name	Gedeon, Brian T.
Attorney Docket No.	BKP-008
Confirmation No.	7653

METHOD OF PAYMENT

1. ☒ Payment Enclosed:
   ☒ Check ☐ Money Order ☐ Other

2. ☒ The Commissioner is hereby authorized to credit or charge any fee indicated below for this submission to Deposit Account No. 50-1721.
   - ☐ Required Fees (copy of this sheet enclosed).
   - ☒ Additional fee required under 37 CFR 1.16 and 1.17.
   - ☒ Overpayment Credit.

3. ☐ Applicant claims small entity status.

FEE CALCULATION

1. FILING/SEARCH/EXAM/SIZE FEES

Large Entity Fee ($)	Fee Description	Fee Paid
300	Utility filing fee	
500	Utility search fee	
200	Utility exam fee	
250	Utility size fee (each add'l 50 pgs. over 100)	
200	Design filing fee	
100	Design search fee	
130	Design exam fee	
250	Design size fee (each add'l 50 pgs. over 100)	

	Number Filed	Number Extra	Rate	Amount
Total Claims	- 20 =		x $ 50.00 =	
Independent Claims	- 3 =		x $200.00 =	
☐ Multiple Dependent Claim(s), if any			$360.00 =	

TOTAL:
SMALL ENTITY DISCOUNT:
SUBTOTAL (1) ($)

2. AMENDMENT CLAIM FEES

	Claims Remaining After Amend.	Highest No. Previously Paid For	Present Extra	Rate	Fee Paid
Total	-		=	x $ 50.00 =	
Indep.	-		=	x $200.00 =	
☐ First Presentation of Multiple Dep. Claim				+ $360.00 =	

TOTAL: ($)
SMALL ENTITY DISCOUNT: ($)
SUBTOTAL (2) ($)

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee ($)	Small Entity Fee ($)	Fee Description	Fee Paid
130	65	Surcharge - late filing fee or oath	
50	25	Surcharge - late provisional filing fee or cover sheet	
130	130	Non-English specification	
2,520	2,520	Request for ex parte reexamination	
120	60	Extension for reply within first month	
450	225	Extension for reply within second month	
1020	510	Extension for reply within third month	
1590	795	Extension for reply within fourth month	
2160	1080	Extension for reply within fifth month	
500	250	Notice of Appeal	
500	250	Filing a brief in support of an appeal	
1000	500	Request for oral hearing	
400	400	Petitions to the Commissioner (Gp. I)	
200	200	Petitions to the Commissioner (Gp. II)	
130	130	Petitions to the Commissioner (Gp. III)	
180	180	Submission of Information Disclosure Statement	
790	395	Filing a submission after final rejection (37 CFR 1.129(a))	
790	395	For each additional invention to be examined (37 CFR 1.129(b))	
100	100	Certificate of Correction for applicant's error	100.00
130	65	Submission of Terminal Disclaimer	
Other fee (Specify)			
Other fee (Specify)			

SUBTOTAL (3) ($) 100.00

SUBTOTAL (1)	
SUBTOTAL (2)	
SUBTOTAL (3)	100.00
TOTAL ($)	100.00

CORRESPONDENCE ADDRESS

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Patent Administrator
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One Lincoln Street
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SIGNATURE BLOCK

Date: August 14, 2007
Reg. No.: 58,343
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Respectfully submitted,
Karen A. Schouten
Karen A. Schouten
Attorney for the Applicant
Kirkpatrick & Lockhart Preston Gates Ellis LLP
State Street Financial Center
One Lincoln Street
Boston, MA 02111-2950

BOS-1112074 v1

AUG 20 2007

PATENT
Attorney Docket No. BKP-008

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

INVENTOR:	Lindstrom
PATENT NO.:	7,221,975
ISSUE DATE:	May 22, 2007
SERIAL NO.:	10/728,081
FILING DATE.:	December 4, 2003
TITLE:	Signal Filtering Using Orthogonal Polynomials and Removal of Edge Effects

ATTN: Certificate of Correction Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REQUEST FOR CERTIFICATE OF CORRECTION

Dear Sir:

The Assignee of record of the above-identified patent, Maquet Critical Care AB, by virtue, at least, of an assignment recorded in the U.S. Patent and Trademark Office (USPTO) on June 13, 2006, at Reel No. 017786, Frame No. 0271, hereby requests that a Certificate of Correction be issued for U.S. Patent No. 7,221,975 pursuant to 35 U.S.C. §§ 254 and 255 and 37 C.F.R. §§ 1.322 and 1.323.

The Assignee requests the correction of errors in the specification and the listing of the claims. In particular, the Assignee requests correction of typographical errors and omissions made by applicant error in (i) the specification column 9, line 13, and column 10, line 60 and (ii) issued claims 4, 10 and 25. Specifically, column 9 of the specification, lines 13-14, recite "...embodiment of the filtering technique according to present invention..." but should read "...embodiment of the filtering technique according to <u>the</u> present invention..." This error is due to an inadvertent omission of the word "the" in the specification by the applicant. In column 10 of the specification, line 60, the misspelling "contiminat<u>i</u>ed" appears rather than the word "contaminated," representing an inadvertent typographical error by the applicant. In claims 4 and 25 the word "Tcheby<u>s</u>hev" is misspelled as "Tcheby<u>c</u>hev" several times, appearing in issued

claim 4, in column 11, lines 59 and 60, and in issued claim 25, in column 14, lines 31-32. Assignee submits that this misspelling is an inadvertent typographical error by the applicant. Finally, in claim 10, appearing in column 12, at line 32 recites the singular "comprise" rather than the plural "comprises," representing an inadvertent typographical error by Applicant.

The Assignee asserts that (i) the foregoing errors are all of a clerical or typographical nature, or of minor character, (ii) such errors occurred in good faith, and (iii) correction of such errors does not involve such changes in the patent as would constitute new matter or would require reexamination. Accordingly, the Assignee encloses the required fee, and respectfully requests that the USPTO issue a Certificate of Correction pursuant to 35 U.S.C. § 255 and 37 C.F.R. § 1.323 to correct such errors.

The Assignee also requests that a Certificate of Correction be issued for correction of certain mistakes incurred through the fault of the USPTO pursuant to 35 U.S.C. § 254 and 37 C.F.R. § 1.322. In particular, the Assignee requests correction of errors and omissions occurring in (i) the specification column 8, line 57, and (ii) issued claims 1, 15, 26, 27, 35, 38, and 54.

The errors in the specification column 8, line 57, and issued claim 38 are evident in light of the claims originally filed on December 4, 2003. Applicants attach as "Exhibit A" a copy of the application as originally filed, including the claims, along with the date-stamped return receipt postcard indicating that the originally filed claims were in fact received by the USPTO. The Assignee submits that no amendments were made to the specification or issued claim 38 after the submission of the original claim set that would be inconsistent with the corrections requested.

Column 8, line 57, corresponds to page 15, line 11 of the originally filed specification. The specification as issued at column 8, line 57, recites "The coefficients C_n, are used..." As shown in Exhibit A, the original specification recites "The coefficients C_n are used..." The Assignee submits that the extra comma in between "C_n" and the word "are" was inadvertently inserted by the Patent Office and should be deleted.

Issued claim 38 corresponds to originally filed claim 39. Issued claim 38 appears in column 16, and at lines 15-16 recites "Tchebyshev U-polynomials. as orthogonal polynomials of higher orders." As shown in Exhibit A, originally filed claim 39 (which corresponds to issued claim 38) recites only "Tchebyshev U-polynomials." without the underlined phrase. The

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Assignee submits that "as orthogonal polynomials of higher orders." was inadvertently added by the Patent Office and should be deleted.

Errors in issued claims 1, 15, 26, 27, 35, and 54 are evident in light of an Amendment and Response submitted to the USPTO on September 8, 2006 (the "Amendment and Response"). A copy of the Amendment and Response, along with a copy of the date-stamped return-receipt postcard, indicating receipt by the USPTO of the Amendment and Response, is attached as "Exhibit B." The Assignee submits that no amendments were made after the submission of the amended claim set appearing in the Amendment and Response that would be inconsistent with the corrections requested.

Issued claim 1 corresponds to amended claim 1 in the Amendment and Response. Issued claim 1 appears in column 11, and at line 46 recites "orders; and;" As shown in Exhibit B, amended claim 1 recites "orders; and" without a semicolon after the word "and." The Assignee submits that the extra semicolon was inadvertently added by the Patent Office and should be deleted.

Issued claim 15 corresponds to amended claim 14 appearing in the Amendment and Response. Issued claim 15 appears in column 13, and at line 4 recites "A method as of filtering..." As shown in Exhibit B, amended claim 14 recites "A method of filtering..." The Assignee submits that the word "as" was inadvertently inserted by the Patent Office and should be deleted.

Issued claim 26 corresponds to new claim 84 appearing in the Amendment and Response. Issued claim 26 appears in column 14, and at line 15 recites "...lower orders from the set of signal substantially..." As shown in Exhibit B, new claim 84 recites "...lower orders from the set of polynomials modeling the contaminated EMG input signal to thereby obtain an EMG input signal substantially..." The Assignee submits that the Patent Office inadvertently deleted the phrase "polynomials modeling the contaminated EMG input signal to thereby obtain an EMG input" and that such phrase should be added to issued claim 26.

Issued claim 27 corresponds to amended claim 22 appearing in the Amendment and Response. Issued claim 27 appears in column 14, and at line 58 recites "means for nonnalizing the time scale..." As shown in Exhibit B, amended claim 22 recites "means for normalizing the

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time scale..." The Assignee believes the Patent Office inadvertently erred as the word "normalizing" is correctly spelled in amended claim 22 in the Amendment and Response.

Issued claim 35 corresponds to amended claim 30 appearing in the Amendment and Response. Issued claim 35 appears in column 15, and at line 66 recites "...the EMG input signal polynomials..." As shown in Exhibit B, amended claim 30 recites "...the EMG input signal as polynomials..." The Assignee submits that the Patent Office inadvertently deleted the word "as" and that such word should be added to issued claim 35.

Issued claim 54 corresponds to amended claim 51 appearing in the Amendment and Response. Issued claim 54 appears in column 18, and at line 20 recites "...the EMG input signal polynomials..." As shown in Exhibit B, amended claim 51 recites "...the EMG input signal as polynomials..." The Assignee submits that the USPTO inadvertently deleted the word "as" and that such word should be added to issued claim 54.

In view of the above, the Assignee respectfully submits that the foregoing errors in U.S. Patent No. 7,221,975 are due to a Patent Office mistake and are therefore correctable pursuant to 35 U.S.C. § 254 and 37 C.F.R. § 1.322.

A copy of a computer generated Form PTO/SB/44 is enclosed. The Assignee believes that the enclosed Form PTO/SB/44 corrects the errors in the specification column 8, line 57, column 9, line 13, and column 10, line 60 and issued claims 1, 4, 10, 15, 25, 26, 27, 35, 38, and 54. The following is a summary of the content of the enclosed Form PTO/SB/44:

Column 8, line 57, after the words 'coefficient C_n' delete ",".

Column 9, line 13, after the words 'according to' insert the word --the--.

Column 10, line 60, the word "contaminatied" should read --contaminated--.

In claim 1, line 46, after the word 'and' delete ";".

In claim 4, lines 59-60, each occurrence of the word "Tchebychev" should read --Tchebyshev--.

In claim 10, line 32, replace the word "comprise" with --comprises--.

In claim 15, line 4, after the word 'method' deleted the word "as".

In claim 25, lines 31-32, each occurrence of the word "Tchebychev" should read --Tchebyshev--.

In claim 26, line 38, after the words 'from the set of' insert the words

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--polynomials modeling the contaminated EMG input signal to thereby obtain an EMG input--.

In claim 27, line 58, the word "nonnalizing" should read --normalizing--.

In claim 35, line 66, after the word 'signal' insert the word --as--

In claim 38, lines 15-16, after the period, the words "as orthogonal polynomials of higher orders" should be deleted.

In claim 54, line 20, after the word 'signal' insert the word --as--.

For the reasons described herein, the Assignee believes that the errors described above warrant issuance of a Certificate of Correction for U.S. Patent No. 7,221,975. Accordingly, the Assignee encloses the aforementioned Form PTO/SB/44 to correct the errors in the above-identified patent and requests that the Commissioner issue a Certificate of Correction reflecting the changes to U.S. Patent No. 7,221,975 as they appear on the enclosed Form PTO/SB/44.

The Assignee encloses the required fee and believes no further fee is necessitated by this Request for a Certificate of Correction. If a fee is nevertheless due, please charge Attorney's Deposit Account No. 50-1721. The Patent Office is invited to call the undersigned attorney with any questions concerning submission of this paper.

Respectfully submitted,

Karen A Schouten

Date: August 14, 2007
Reg. No. 58,343

Karen A. Schouten
Attorney for the Assignee
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PTO/SB/44 (08-07)
Approved for use through 08/31/2007. OMB 0651-0033
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

(Also Form PTO-1050)

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,221,975

APPLICATION NO.: 10/728,081

ISSUE DATE : May 22, 2007

INVENTOR(S) : Lindstrom

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 8, line 57, after the words 'coefficient Cn' delete ",".
Column 9, line 13, after the words 'according to' insert the word --the--.
Column 10, line 60, the word "contaminatied" should read --contaminated--.
In claim 1, line 46, after the word 'and' delete ";".
In claim 4, lines 59-60, each occurrence of the word "Tchebychev" should read --Tchebyshev--.
In claim 10, line 32, replace the word "comprise" with --comprises--.
In claim 15, line 4, after the word 'method' deleted the word "as".
In claim 25, lines 31-32, each occurrence of the word "Tchebychev" should read --Tchebyshev--.
In claim 26, line 38, after the words 'from the set of' insert the words --polynomials modeling the contaminated EMG input signal to thereby obtain an EMG input--.
In claim 27, line 58, the word "nonnalizing" should read --normalizing--.
In claim 35, line 66, after the word 'signal' insert the word --as--
In claim 38, lines 15-16, after the period, the words "as orthogonal polynomials of higher orders" should be deleted.
In claim 54, line 20, after the word 'signal' insert the word --as--.

MAILING ADDRESS OF SENDER (Please do not use customer number below):

Patent Administrator, Kirkpatrick & Lockhart Preston Gates Ellis LLP, State Street Financial Center, One Lincoln Street, Boston, MA 02111-2950

AUG 2 0 2007

BKP-008
(9615/__)

The "RECEIVED" stamp of the Patent Office imprinted hereon acknowledges the filing of:

Utility Patent Application Transmittal Form (1 pg.); Application Data Sheet (2 pgs.); Utility Application (including Specification - 20 pgs., Claims -16 pgs., Abstract - 1 pg, and Formal Drawings - 12 sheets); and this return receipt postcard, with each paper and fee having Express Mail Mailing Label No. EL988705660US, thereon.

Name of Applicant:	Lindström
Serial Number:	Not Yet Assigned
Atty:	TATurano/SKWitonsky
Date:	December 4, 2003

2719925

Express Mail Mailing Label No. EL988705660US
U.S. Patent Application
Attorney Docket No. BKP-008

SIGNAL FILTERING USING ORTHOGONAL POLYNOMIALS AND REMOVAL OF EDGE EFFECTS

FIELD OF THE INVENTION

The present invention relates to a method and device for filtering an input signal containing wanted signal components and unwanted signal components.

BACKGROUND OF THE INVENTION

Characteristics of typical signals, disturbances, noise and interference including myoelectric (EMG) signals, cardiac (ECG) signals, movement-induced disturbances, background noise, and interference from the mains will be first reviewed.

Myoelectric (EMG) signal

An EMG signal reflects the nervous activation of a muscle or a group of muscles, and presents the character of a band-limited noise in extra-muscular readings. The strength and spectral contents of an EMG signal are determined by the following parameters:

(1) the number of motor units (muscles) recruited;
(2) the repetition rate of motor unit activation;
(3) the distance between the source (fibers of the muscle(s)) and the electrode(s) used to sense the EMG signal;
(4) the width of the innervation zone;
(5) the propagation velocity of the activation potentials;
(6) the electrode configuration including, for example, the distance between electrode plates, the parallel or perpendicular alignment of the electrode plates with respect to the direction of the fibers of the muscle(s), etc.; and
(7) other parameters such as the length of the fibers of the muscle(s), the position of

the electrode(s) with respect to both the innervation zone and the ends of the fibers of the muscle(s), etc.

For many muscles, except very short muscles, the above-mentioned parameters produce a spectrum whose amplitude increases from zero at zero frequency (Direct Current (DC)), presents a peak in the region of 40-100 Hz and, then, decreases gradually as the frequency increases.

Models that take into consideration the above listed parameters show that these parameters are multiplicative in the frequency domain, indicating that the time dependent signals are multiple convolutions of the phenomena associated with these parameters. The time representation of an EMG signal is thus very complex, and most attempts to process such a signal has consequently involved filtering of the EMG signal through certain frequency-filtering characteristics.

Electrocardiogram (ECG) signal

An ECG signal is generated from electrical activity of the heart, which is rather coherent in space and time. Thus, an ECG signal has a deterministic character in the time domain except under certain pathological conditions such as fibrillation. In the frequency domain, maximum density of the spectral energy is found in the region around 10-15 Hz with the spectral energy density decreasing as the frequency increases.

Since contributions to the ECG signal are synchronized, the ECG signal has a much higher energy than an EMG signal. Moreover, significant ECG contributions are located in the frequency bandwidth where the density of energy of an EMG signal is maximal, whereby ECG is likely to disturb an EMG signal.

Movement induced disturbance

Movement of the electrodes cause variations in the electrode contact resistance and electrode contact capacitance, which modulate the (half-battery) voltage across the

metal-tissue junction to cause a corresponding disturbance. This disturbance, often referred to as "varying baseline", has high-amplitude low-frequency spectral components since it is caused by a slow mechanical movement. The frequency characteristic of this disturbance is often lower in frequency than the frequency characteristic associated with the time window of the signal epoch and, thus, this disturbance manifests itself as a large offset DC component.

It is also observed that variations in the baseline are equivalent to variations in the spectral components above DC (zero frequency). Therefore, the large potential behind baseline variations (magnitude of the order of, for example, one volt) also makes the spectrum density of the variation significant.

Background noise

In addition to the above-mentioned signal contributions, there is a noise component. This noise component has a rather unspecific character and originates from a number of different sources. It is often modelled as a random component with constant (or slowly varying) spectral density in the whole frequency bandwidth of interest.

Interference from the mains

Interference from the mains has a well-defined signal shape with a fixed frequency. Unknown parameters of this interference are the phase and the amplitude, which may vary considerably.

Currently used filter techniques to separate signal contributions

In the following description, some of the problems associated with the separation of signal components such as EMG, ECG, baseline variations, and noise will be discussed. Drawbacks associated with currently used signal filtering methods will also be considered.

EMG signal vs. movement induced disturbance

Although rather separated in frequency, the high energy density of the movement induced disturbances becomes significant also in the frequency bandwidth where EMG signals have a maximum amplitude. Recursive filtering is often used to remove movement induced disturbances from EMG signals. However, recursive filtering presents the drawback of suffering from the long time it takes to forget the high energy input from a sudden baseline variation. For that reason, recursive filtering should be avoided.

EMG signal vs. background noise

The spectra of EMG signal and background noise overlap and both have a character of random noise. Optimum (Wiener) filtering can be used, but a low-pass filter cutting off the high frequency portion of the noise can be sufficient since this will remove the major portion of the background noise.

EMG signal vs. ECG signal

As indicated in the foregoing description, EMG and ECG signals have partly overlapping power spectra. Strong ECG signals create significant spectral energy density at frequencies where energy peaks of the EMG signals appear. Efficient filtering to remove an ECG signal from an EMG signal or vice versa should use the deterministic character of the ECG signal in the time domain.

ECG signal vs. movement induced disturbance

ECG signals and movement induced disturbances have respective spectra with a considerable overlap and are difficult to separate in the frequency domain. The deterministic character of ECG in the time domain is often utilized, in particular for averaging QRS complexes. A drawback of such filtering is that it introduces in the output from the filter a delay having a duration as long as ten (10) seconds.

ECG signal vs. background noise

Although ECG signals and background noise overlap in the low frequency region of the spectrum, the ECG signal is mostly dominating and, therefore, a low-pass filtering is normally sufficient to remove most of the background noise from an ECG recording.

Movement induced disturbance vs. background noise

Although this case is of interest in quality control of the signal, this issue will not be further elaborated in the present specification.

Interference from the mains and power line interference

A common technique for removing an interference from the mains and a power line interference is to process the disturbed signal through a notch filter which is quite sharp at the particular frequency of these interferences. This solution presents the drawback that a notch filter introduces large phase shifts in the remaining part of the signal. As mentioned hereinabove, the nature of these interferences is "a priori" well known, and their frequency is mostly constant. Only the start instant within the oscillation, the phase, and the amplitude are unknown and have to be calculated. This "a priori" knowledge implies that single periods or even portions of the interference oscillation can be used to perform the latter calculation.

From the above-described characteristics of the various signal contributions, the following acknowledgments can be made:

- Filtering in the frequency domain requires very steep filters to extract the EMG signal and to suppress the ECG signal and the interference from the mains. Steep filters present the drawback of being associated with large phase shifts and ringing.

- Since the baseline variations are large and slow, recursive filtering should be avoided since these filters have a memory of past events.

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- Filtering should occur over finite epoch lengths, and Infinite Impulse Response (IIR) filters should not be used.

- Filters designed from a frequency-domain point of view present the drawbacks of having 1) slow convergence since the trigonometric series are not well suited to describe baseline variations, 2) remaining memory of earlier events due to their (often) recursive character, and 3) large phase shifts and ringing in proportion of their sharpness.

In view of the above, a new filtering technique is needed to efficiently isolate or remove one or many of the above discussed signal contributions from an input signal.

SUMMARY OF THE INVENTION

More specifically, in accordance with the present invention, there is provided a method of filtering an input signal containing wanted signal components and unwanted signal components, comprising modeling the input signal as a set of polynomials, identifying polynomials from the set to model the unwanted signal components, and removing the unwanted signal components from the input signal by removing the polynomials identified as modeling the unwanted signal components from the set of polynomials to thereby leave in the input signal only the wanted signal components.

The present invention also relates to a device for filtering an input signal containing wanted signal components and unwanted signal components, comprising means for modeling the input signal as a set of polynomials, means for identifying polynomials from the set to model the unwanted signal components, and means for removing the unwanted signal components from the input signal, wherein the unwanted signal components removing means comprises means for removing the polynomials identified as modeling the unwanted signal components from the set of polynomials to thereby leave in the input signal only the wanted signal components.

Further in accordance with the present invention, there is provided a method of filtering an input signal containing wanted signal components and unwanted signal components, comprising modeling the input signal as a set of polynomials, identifying polynomials from the set to model the wanted signal components, and outputting the polynomials identified as modeling the wanted signal components as an estimate of the input signal substantially free from the unwanted signal components.

The present invention further relates to a device for filtering an input signal containing wanted signal components and unwanted signal components, comprising means for modeling the input signal as a set of polynomials, means for identifying polynomials from the set to model the wanted signal components, and means for outputting the polynomials identified as modeling the wanted signal components as an estimate of the input signal substantially free from the unwanted signal components.

Still further in accordance with the present invention, there is provided a method of filtering an input signal containing wanted signal components and unwanted signal components, comprising modeling the input signal as a set of polynomials, determining, for each polynomial, a weighting coefficient indicative of signal strength, and summing the weighting coefficients to provide an estimate of the strength of the wanted signal components.

The present invention still further relates to a device for filtering an input signal containing wanted signal components and unwanted signal components, comprising means for modeling the input signal as a set of polynomials, means for determining, for each polynomial, a weighting coefficient indicative of signal strength, and means for summing the weighting coefficients to provide an estimate of the strength of the wanted signal components.

The foregoing and other objects, advantages and features of the present invention will become more apparent upon reading of the following non-restrictive description of illustrative embodiments thereof, given by way of example only with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the appended drawings:

Figure 1 is a schematic flow chart illustrating a technique according to a non-restrictive illustrative embodiment of the present invention, using orthogonal polynomials to model an input, contaminated signal;

Figure 2 illustrates, as an example, normalized Legendre orthogonal polynomials in an interval $-1<x<1$, of degrees zero (0) to seven (7) used for filtering finite length signal epochs;

Figure 3 is a schematic flow chart of a first method according to a non-restrictive illustrative embodiment of the present invention, for filtering an input signal having wanted signal components and unwanted signal components;

Figure 4 is a schematic flow chart of a second method according to a non-restrictive illustrative embodiment of the present invention, for filtering an input signal having wanted signal components and unwanted signal components;

Figure 5 is a schematic flow chart of a third method according to a non-restrictive illustrative embodiment of the present invention, for filtering an input signal having wanted signal components and unwanted signal components;

Figure 6 is a schematic flow chart of a technique according to a non-restrictive, illustrative embodiment of the present invention, for eliminating edge effects;

Figure 7 illustrates a non-restrictive example of contaminated input signal (upper trace) splitted into overlapping windows, including odd windows (middle trace) and even windows (lower trace);

Figure 8 is a non-limitative example of unwanted signal components modeled in the

odd and even windows of Figure 7 by signals synthesized from Legendre polynomials of orders zero (0) to seven (7);

Figure 9 are examples of signal parts remaining after removal from the input signal of the signals of Figure 8, modeling the unwanted signal components;

Figure 10 illustrates non-limitative examples of edge effect suppressing functions in the respective odd and even windows of Figure 7;

Figure 11 are examples of weighted signal parts obtained by multiplying the signal parts of Figure 9 with the edge effect suppressing functions in the respective odd and even windows of Figure 7; and

Figure 12 are examples of the input contaminated signal (upper trace) and the filtered signal (lower trace) obtained by summing the weighted signal part of the various overlapping windows.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENT

From the analysis of the EMG signals, ECG signals, movement induced disturbances, background noise, and interference from the mains made in the "background of the invention" of the present specification, the following conclusions can be drawn:

- The "a priori" knowledge of the input signal could be used for designing the filtering technique. One example is the interference from the mains, which has substantially sinusoidal shape and fixed frequency.

- The filtering technique could model the disturbances, offsets, trends, noise, etc., in a more efficient manner than the Fourier transform is capable of. Other functions requiring a smaller set of terms could be used to more efficiently model the essential features of the signal.

- DC components could be removed from finite length epochs since these components have frequencies lower than the lowest frequency associated to the epoch.

- Trends could be removed from the signal. The reason for this time domain processing is that a ramp has a large number of harmonics when decomposed in the Fourier domain.

- The frequency characteristics of the filtering technique could be preserved at higher frequencies in order to fully benefit from experiences of spectral filtering.

- Since trigonometric functions do not fulfill the above requirements in the low frequency region of the spectrum, polynomials or other functions could be used to comply with the requirements associated to DC, ramp and oscillatory behaviour at higher frequencies.

- Orthogonal sets of functions could be used in the filtering technique so that modifications of the filter components do not mutually influence each other.

Keeping the above in mind, the non-restrictive illustrative embodiments of the method and device according to the present invention are concerned with a filtering technique intended primarily for supplying filtered signals from contaminated signals of various kinds. Although this filtering technique could be used in a plurality of different applications, the illustrative embodiments relate to filtering of bioelectric signals.

More specifically, the description of the illustrative embodiments of the method and device in accordance with the present invention will focus on the filtering of EMG signals (wanted signal components) contaminated with ECG signals, movement induced disturbances, and background noise (unwanted signal components). The goal of the illustrative embodiments is to obtain a filtered EMG signal from a contaminated esophageal recording in view of controlling a mechanical ventilator.

Another possible application in the bioelectric field is to remove baseline variations (unwanted signal components) from ECG signals (wanted signal components) in view of obtaining immediate estimates of ST-depressions instead of averaging these ST-depressions over a number of QRS complexes, which delays the estimation process.

In yet another possible application, wanted signal components comprise internal variations of a QRS complex of an ECG signal and the unwanted signal components comprise a remaining part of the ECG signal. This enables investigation of internal variations of electric propagation within the heart muscle for the purpose of studying heart arrhythmia.

Filtering with orthogonal polynomials

A non-restrictive illustrative embodiment of the present invention proposes to use orthogonal, normalized polynomials to model the unwanted signal components in the contaminated signal. Once modeled, it is easier to remove the unwanted signal components from a contaminated input signal in order to obtain a corresponding, filtered signal substantially free from these unwanted signal components.

Another non-restrictive illustrative embodiment of the present invention is to model the wanted signal components and to use this model as an estimate of the filtered signal generally free from the unwanted signal components.

A non-restrictive illustrative embodiment of a method for modeling signal components of a contaminated signal will now be described.

Operation 11 (Figure 1)

Referring to Figure 1, let's consider a signal epoch *S(t)* in a limited time interval.

Operation 12 (Figure 1)

The time scale of the epoch *S(t)* is normalized. For that purpose, the limited time interval under consideration is shifted and scaled into a new variable *x* in an interval $-1<x<1$. The signal epoch under consideration then becomes *S(x)*.

Operation 13 (Figure 1)

The signal epoch *S(x)* is described in terms of a set of orthogonal polynomials $Q_n(x)$. A first initial polynomial $Q_0(x)$ has a constant value, for example proportional to the DC component. A second initial polynomial $Q_1(x)$ has a constant slope, for example proportional to a trend. Thus:

$$Q_0(x) = \text{Constant} \qquad (1)$$

and

$$Q_1(x) = \text{Constant} \times x \qquad (2)$$

Another condition requires the polynomials to be orthogonal, i.e. that:

$$\int_{-1}^{+1} Q_m(x)\ Q_n(x)\ f(x)\ dx = \begin{cases} 0 & \text{for } m \neq n \\ K_n \neq 0 & \text{for } m = n \end{cases} \qquad (3)$$

where *f(x)* is a function of *x* and K_n is a constant depending only on the order *n*.

The conditions given in equations (1) to (3) are fulfilled by several types of polynomials, which are orthogonal in the interval $-1<x<1$. Non-restrictive examples are the Legendre polynomials, Tchebyshev T-polynomials, and Tchebyshev U-polynomials.

As a non limitative example, Figure 2 illustrates polynomials, orthogonal in the interval $-1<x<1$, of degrees zero (0) to seven (7) used for filtering finite length signal epochs. The functions in the plot of Figure 2 are normalized Legendre polynomials.

The following Table 1 lists some of the properties of the above-mentioned Legendre polynomials, Tchebyshev T-polynomials, and Tchebyshev U-polynomials.

Table 1:
Some characteristics of polynomials being orthogonal in the interval $-1<x<1$

Type	***f(x)***	K_n	$Q_0(x)$	$Q_1(x)$	$Q_2(x)$	$Q_3(x)$
Legendre	1	$2/(2n+1)$	1	x	$(3x^2-1)/2$	$(5x^3-3x)/2$
Tchebyshev T	$(1-x^2)^{-1/2}$	$\pi/2$ (§)	1	x	$2x^2-1$	$4x^3-3x$
Tchebyshev U	$(1-x^2)^{1/2}$	π	1	$2x$	$4x^2-1$	$8x^3-4x$

(§) $K_0 = \pi$. Also, in the synthesis (equation (4)), a factor of 0.5 is required for n=0.

The contaminated input signal can be synthesized from a sum of these polynomials:

$$S(x)=\sum_{n=0}^{\infty} C_n \; Q_n(x) \qquad (4)$$

where

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x) \; Q_n(x) \; f(x) \; dx \qquad (5)$$

In practice, a limited number of terms is used. One reason is that terms of increasing order reflect increasing frequencies, which corresponds to regions containing little information.

The filtering technique can be conducted in accordance with different methods. The choice of the method will depend on the number of numeric calculations involved.

Obviously, the longer the series of polynomials the more complicated the filtering procedure. For that reason, too long a series of polynomials will be avoided.

First method (Figure 3)

In accordance with a non-restrictive illustrative embodiment of the present invention, a first filtering method comprises the following operations:

1. The particular orders of the polynomials associated with the unwanted signal components are identified (Operation 31);

2. The unwanted signal components are modeled as a sum of polynomials (equation (4) and Operation 32) weighted by means of the coefficients C_n (equation (5)); and

3. This model of the unwanted signal components is removed from the input, contaminated signal, more specifically from the other polynomials of the original set to obtain the filtered signal substantially free from these unwanted signal components (Operation 33).

Second method (Figure 4)

In accordance with a non-restrictive illustrative embodiment of the present invention, a second filtering method comprises the following operations:

1. The particular orders of the polynomials of the set associated with the wanted signal components are identified (Operation 41);

2. The wanted signal components are modeled as a sum of polynomials (equation (4) and Operation 42) weighted by the coefficients C_n; and

3. The sum of weighted polynomials is outputted as an estimate of the filtered signal, substantially free from the unwanted signal components (Operation 43).

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Third method (Figure 5)

This third method is used when only a representation of the strength of the signal is wanted. The third method can proceed according to the above-described second method (Figure 4) while avoiding the signal synthesis (modeling of the wanted signal components as a sum of weighted polynomials as described in equation (4)), using instead the coefficients C_n to model the strength of the wanted signal components.

More specifically, according to this third method:

1. The coefficients C_n are used as estimates for the signal strength (Operation 51) to thereby model the strength of the wanted signal components.

2. The set of coefficients C_n are then added to provide an estimate of the strength of the wanted signal components (Operation 52). As a non-restrictive illustrative example, the coefficients C_n are summed on a square law basis to give an estimate of the signal power, for example by summing squared coefficients C_n. This summation on a square law basis is performed with additional weighting for the order n of the polynomial Q_n. In particular, for the Legendre polynomials, this weighting factor is K_n and the square RMS value is given by:

$$RMS^2 = (1/2)\sum C_n{}^2 K_n$$

Corresponding constructions can be derived for other types of polynomials.

Those of ordinary skill in the art will appreciate that the RMS value of the synthesized signal according to equation (4) is equivalent to the summation of the coefficients C_n on a square law basis followed by a square root calculation.

With an application of the non-restrictive illustrative embodiment of the filtering technique according to present invention to EMG signal processing, it has been observed that the polynomials of lowest orders mimic the baseline variations and

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polynomials of somewhat higher orders describe the ECG quite well. It has further been observed that the above-described second and third method automatically eliminate high frequency noise.

It should also be pointed out that Legendre polynomials of higher orders present an oscillatory behaviour thereby making it possible to obtain estimates for the dominating periodicity of the wanted signal components. The weighting coefficients C_n are summed on a square law basis with a weighting proportional to the number of oscillations for the order n of the polynomial Q_n, normalized with respect to the sum of the weighting coefficients C_n on a square law basis with polynomial order weighting K_n, in order to obtain the dominating periodicity of the wanted signal components. This provides an estimated number of oscillations (FRQ) in the signal interval $-1 \leq x \leq 1$:

$$FRQ = \frac{\sum C_n^2 K_n (n/2)}{\sum C_n^2 K_n}$$

Similar constructions can be derived for other types of polynomials.

Windowing to remove edge effects

Equation (4) shows that an infinite number of polynomials are needed to fully represent the characteristics of the signal. If the summation is done over a limited number of polynomials, edge effects similar to those found in Fourier synthesis will occur. These edge effects are constituted by oscillations whose strength and frequency depend on the number of sinusoidal harmonic terms that are summated. More specifically, the edge effects can be described as being constituted by imperfections having a strength depending on the limited number of summated polynomials. The orthogonal polynomials, as described in Table 1 and illustrated in Figure 2, attain large values at the opposite ends of the limited time interval. There is also a shift in sign between polynomials of adjacent orders at x=-1.

These edge effects may have a large influence on the filtered signal and have to

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be considered. To suppress the influence of the edge effects on the filtered signal the following edge effect removal method according to a non-restrictive illustrative embodiment of the present invention can be used:

Operation 601 (Figure 6)

Overlapping windows are first defined. As a non-limitative example, 50% overlapping windows such as odd windows 74 and even windows 75 of Figure 7 can be used. Although the example of Figure 7 uses 50% overlapping windows, it is within the scope of the present invention to use many other types of suitable overlapping windows.

Operation 602 (Figure 6)

Filtering in accordance with one of the above-described methods is conducted in the overlapping windows, for example the windows 74 and 75 in Figure 7.

Operation 603 (Figure 6)

A weighting is conducted to suppress the signal at the opposite ends of each window and emphasize the signal in the central part of the same windows.

In the non-restrictive, illustrative embodiment of the filtering technique according to the present invention, the signal weighting is conducted in the various windows by means of respective edge effect suppressing functions constructed in such a way that the sum of the functions from the different overlapping windows is equal to unity (see for example functions 101 and 102 of Figure 10).

In a non-restrictive illustrative embodiment of the present invention, since the sum of the weighting function for windows 74 and the weighting function for windows 75 is equal to unity, and the value of the weighting functions at the opposite ends of the respective windows is equal to zero in order to suppress the edge effects, the following conditions are met for such a weighting window:

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$$W(x=-1) = W(x=+1) = 0 \qquad (6)$$

and

$$W(x) + W(1-x) = 1 \qquad (7)$$

This implies that

$$W(0) = 1 \qquad (8)$$

and

$$W(-x) = W(x) \qquad (9)$$

There are a number of functions capable of fulfilling these conditions. Two might be mentioned: a triangular function (equation (10a)) and a squared cosine function (equation (10b)).

$$W(x) = 1 - |x| \qquad (10a)$$

$$W(x) = cos^2(\pi x/2) \qquad (10b)$$

The function of equation (10b) presents the characteristics of having continuous derivatives and to suppress the signal more efficiently at the opposite ends of the window.

Operation 604 (Figure 6)

The overlapping signal parts (see for example signal parts 111 and 112 of Figure 11) are then summated to give the output, filtered signal (see for example signal 122 of Figure 12) free from the unwanted signal components.

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Example (Figures 7-12)

A non-limitative example, corresponding to a combination of the first filtering method (Figure 3) and windowing (Figure 6), will now be described with reference to Figures 7-12.

Referring to Figure 7, the input contaminatied signal (upper trace 71) is splitted into 50% overlapping windows such as 74 and 75 numbered in sequence order, including odd windows 74 (middle trace 72), and even windows 75 (lower trace 73).

In this non-limitative example, as illustrated in Figure 8, the unwanted signal components in the middle 72 and lower 73 traces of Figure 7 are modeled in every window 74 and 75 as signals 81 and 82, respectively, synthesized from Legendre polynomials of orders zero (0) to seven (7).

Figure 9 shows the signal parts 91 remaining after removal of the signal 81 (Figure 8) in the odd windows 74 (middle trace 72) of Figure 7. In the same manner, Figure 9 shows the signal parts 92 remaining after removal of the signal 82 (Figure 8) in the even windows 75 (lower trace 73) of Figure 7.

Figure 10 illustrates an edge effect suppressing function 101, corresponding to equation (10b), in each odd window 74 for smoothing transitions from one odd window 74 to the other. In the same manner, Figure 10 illustrates an edge effect suppressing function 102, corresponding to equation (10b), in each even window 77 for smoothing transitions from one even window 75 to the other.

In Figure 11, the signal parts 111 of the odd windows are obtained by multiplying the remaining signal parts 91 of Figure 9 by the edge effect suppressing function 101 of the odd windows 74. In the same manner, the signal parts 112 (even windows) of Figure 12 are obtained by multiplying the remaining signal parts 92 of Figure 9 by the edge effect suppressing function 102 of the even windows 75. Multiplication of the remaining signal parts 91 by the function 101 has the effect of suppressing the above-described edge effects related to the odd windows 74. In the same manner, multiplication of the

remaining signal parts 92 by the function 102 has the effect of suppressing the above-described edge effects related to the even windows 75.

Finally, in Figure 12, the upper trace 121 corresponds to the input contaminated signal to be filtered as illustrated in the upper trace 71 of Figure 7. The lower trace 122 of Figure 12 is the processed signal from which the unwanted signal components have been filtered out, and corresponds to the summation of signal parts 111 (corresponding to the odd windows 74) and 112 (corresponding to the even windows 75) of Figure 11.

Although the present invention has been described hereinabove in connection with illustrative embodiments thereof, these illustrative embodiments can be modified at will, within the scope of the appended claims without departing from the spirit and nature of the present invention.

WHAT IS CLAIMED IS:

1. A method of filtering an input signal containing wanted signal components and unwanted signal components, comprising:

modeling the input signal as a set of polynomials;

identifying polynomials from the set to model the unwanted signal components; and

removing the unwanted signal components from the input signal by removing the polynomials identified as modeling the unwanted signal components from the set of polynomials to thereby leave in the input signal only the wanted signal components.

2. A method as defined in claim 1, wherein the wanted signal components comprise a myoelectric signal and the unwanted signal components comprise at least one of the following disturbances: a cardiac signal, a motion disturbance, and background noise.

3. A method as defined in claim 1, wherein the wanted signal components comprise an ECG signal and the unwanted signal components comprise baseline variations.

4. A method as defined in claim 1, wherein the wanted signal components comprise internal variations of a QRS complex of an ECG signal and the unwanted signal components comprise a remaining part of the ECG signal.

5. A method as defined in claim 1, wherein modeling the input signal as a set of polynomials comprises:

considering an epoch *S(t)* of the input signal in a limited time interval, said epoch *S(t)* having a time scale; and

normalizing the time scale of the epoch *S(t)*.

6. A method as defined in claim 5, wherein normalizing the time scale of the epoch *S(t)* comprises:

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shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes $S(x)$.

7. A method as defined in claim 1, wherein modeling the input signal as a set of polynomials comprises modeling the input signal as a set of orthogonal polynomials.

8. A method as defined in claim 6, wherein modeling the input signal as a set of polynomials comprises modeling the input signal as a set of orthogonal polynomials $Q_n(x)$.

9. A method as defined in claim 8, wherein the set of orthogonal polynomials $Q_n(x)$ comprises:

a first initial polynomial $Q_0(x)$ having a constant value; and

a second initial polynomial $Q_1(x)$ having a constant slope.

10. A method as defined in claim 7, comprising selecting the orthogonal polynomials from the group consisting of:

Legendre polynomials;

Tchebyshev T-polynomials; and

Tchebyshev U-polynomials.

11. A method as defined in claim 8, wherein modeling the input signal as a set of polynomials comprises:

expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \; Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x) \; Q_n(x) \; f(x) \; dx$$

where $f(x)$ is a function of x and K_n is a constant depending on the order n.

12. A method as defined in claim 11, wherein identifying polynomials from the set

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to model the unwanted signal components comprises:

associating particular orders of the polynomials with the unwanted signal components; and

modeling the unwanted signal components as a sum of the polynomials of said particular orders, comprising weighting the polynomials of said particular orders by means of the coefficients C_n.

13. A method as defined in claim 12, wherein removing the polynomials identified as modeling the unwanted signal components from the set of polynomials comprises:

removing the sum of weighted polynomials from the sum of polynomials $Q_n(x)$.

14. A method as defined in claim 1, wherein:

modeling the input signal as a set of polynomials comprises modeling the input signal as a sum of a limited number of polynomials; and

said method further comprises eliminating edge effects constituted by imperfections having a strength depending on the limited number of polynomials.

15. A method as defined in claim 14, wherein:

eliminating the edge effects comprises defining overlapping windows;

identifying polynomials from the set to model the unwanted signal components comprises identifying, in each window, polynomials from the set to model the unwanted signal components;

removing the unwanted signal components from the input signal comprises removing, in each window, the polynomials identified as modeling the unwanted signal components from the set of polynomials to thereby produce in said window a filtered signal part; and

eliminating edge effects further comprises:

in each window, weighting the filtered signal part to suppress the filtered signal part at opposite ends of the window and emphasize the filtered signal part in the central portion of said window; and

summing the weighted filtered signal parts of the overlapping windows to form an output filtered signal generally free from edge effects.

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16. A method as defined in claim 15, wherein defining overlapping windows comprises:

defining 50% overlapping windows.

17. A method as defined in claim 15, wherein weighting the filtered signal part in each window comprises:

providing for each window an edge effect suppressing function; and

in each window, multiplying the filtered signal part by the edge effect suppressing function of said window.

18. A method as defined in claim 17, wherein providing for each window an edge effect suppressing function comprises:

constructing an edge effect suppressing function in such a manner that:

- a sum of the edge effect suppressing functions of the various overlapping windows is equal to unity; and
- a value of the edge suppressing function at opposite ends of each window is equal to zero.

19. A method as defined in claim 18, comprising selecting the edge effect suppressing functions of the overlapping windows from the group consisting of: a triangular function and a squared cosine function.

20. A method as defined in claim 1, wherein modeling the input signal as a set of polynomials comprises:

using higher order polynomials that mimic an oscillatory pattern of the input signal.

21. A device for filtering an input signal containing wanted signal components and unwanted signal components, comprising:

means for modeling the input signal as a set of polynomials;

means for identifying polynomials from the set to model the unwanted signal components; and

means for removing the unwanted signal components from the input signal,

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wherein the unwanted signal components removing means comprises means for removing the polynomials identified as modeling the unwanted signal components from the set of polynomials to thereby leave in the input signal only the wanted signal components.

22. A device as defined in claim 21, wherein the input signal modeling means comprises:

means for considering an epoch $S(t)$ of the input signal in a limited time interval, said epoch $S(t)$ having a time scale; and

means for normalizing the time scale of the epoch $S(t)$, wherein said time scale normalizing means comprises means for shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes $S(x)$.

23. A device as defined in claim 22, wherein the input signal modeling means comprises:

means for modeling the input signal as a set of orthogonal polynomials $Q_n(x)$.

24. A device as defined in claim 23, wherein the set of orthogonal polynomials $Q_n(x)$ comprises:

a first initial polynomial $Q_0(x)$ having a constant value; and

a second initial polynomial $Q_1(x)$ having a constant slope.

25. A device as defined in claim 24, wherein the input signal modeling means comprises:

means for expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \; Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x) \; Q_n(x) \; f(x) \; dx$$

where $f(x)$ is a function of x and K_n is a constant depending on the order n.

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26. A device as defined in claim 25, wherein:

the input signal modeling means comprises means for modeling the input signal as a sum of a limited number of polynomials; and

said device further comprises means for eliminating edge effects constituted by imperfections having a strength depending on the limited number of polynomials.

27. A device as defined in claim 26, wherein:

the edge effects eliminating means comprises means for defining overlapping windows;

the polynomials identifying means comprises means for identifying, in each window, polynomials from the set to model the unwanted signal components;

the unwanted signal components removing means comprises means for removing, in each window, the polynomials identified as modeling the unwanted signal components from the set of polynomials to thereby produce in said window a filtered signal part; and

the edge effects eliminating means further comprises:

for each window, means for weighting the filtered signal part to suppress the filtered signal part at opposite ends of the window and emphasize the filtered signal part in the central portion of said window; and

means for summing the weighted filtered signal parts of the overlapping windows to form an output filtered signal generally free from edge effects.

28. A device as defined in claim 27, wherein the overlapping windows comprise 50% overlapping windows.

29. A device as defined in claim 27, wherein the filtered signal part weighting means comprises:

means for providing for each window an edge effect suppressing function; and

means for multiplying, in each window, the filtered signal part by the edge effect suppressing function of said window.

30. A method of filtering an input signal containing wanted signal components

and unwanted signal components, comprising:

modeling the input signal as a set of polynomials;

identifying polynomials from the set to model the wanted signal components; and

outputting the polynomials identified as modeling the wanted signal components as an estimate of the input signal substantially free from the unwanted signal components.

31. A method as defined in claim 30, wherein the wanted signal components comprise a myoelectric signal and the unwanted signal components comprise at least one of a cardiac signal, motion disturbance, and background noise.

32. A method as defined in claim 30, wherein the wanted signal components comprise an ECG signal and the unwanted signal components comprise baseline variations.

33. A method as defined in claim 30, wherein the wanted signal components comprise internal variations of a QRS complex of an ECG signal and the unwanted signal components comprise a remaining part of the ECG signal.

34. A method as defined in claim 30, wherein modeling the input signal as a set of polynomials comprises:

considering an epoch *S(t)* of the signal in a limited time interval, said epoch *S(t)* having a time scale; and

normalizing the time scale of the epoch *S(t)*.

35. A method as defined in claim 34, wherein normalizing the time scale of the epoch *S(t)* comprises:

shifting and scaling the limited time interval under consideration into a new variable *x* in an interval $-1<x<1$ whereby the signal epoch becomes *S(x)*.

36. A method as defined in claim 30, wherein modeling the input signal as a set of polynomials comprises modeling said input signal as a set of orthogonal polynomials.

37. A method as defined in claim 35, wherein modeling the input signal as a set of polynomials comprises modeling the input signal as a set of orthogonal polynomials $Q_n(x)$.

38. A method as defined in claim 37, wherein the set of orthogonal polynomials $Q_n(x)$ comprises:

a first initial polynomial $Q_0(x)$ having a constant value; and

a second initial polynomial $Q_1(x)$ having a constant slope.

39. A method as defined in claim 36, comprising selecting the orthogonal polynomials from the group consisting of:

Legendre polynomials;

Tchebyshev T-polynomials; and

Tchebyshev U-polynomials.

40. A method as defined in claim 37, wherein modeling the input signal as a set of polynomials comprises:

expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n\ Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x)\ Q_n(x)\ f(x)\ dx$$

where $f(x)$ is a function of x and K_n is a constant depending on the order n.

41. A method as defined in claim 30, wherein identifying polynomials from the set to model the wanted signal components comprises:

identifying orders of the polynomials of the set associated with the wanted signal components.

42. A method as defined in claim 30, further comprising weighting the polynomials identified as modeling the wanted signal components by means of

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weighting coefficients.

43. A method as defined in claim 40, wherein identifying polynomials from the set to model the wanted signal components comprises:

associating particular orders of the polynomials with the wanted signal components; and

modeling the wanted signal components as a sum of the polynomials of said particular orders, comprising weighting the polynomials of said particular orders by means of the coefficients C_n.

44. A method as defined in claim 30, wherein modeling the input signal as a set of polynomials comprises:

using higher order polynomials that mimic an oscillatory pattern of the input signal.

45. A method as defined in claim 30, wherein:

modeling the input signal as a set of polynomials comprises modeling the input signal as a sum of a limited number of polynomials; and

said method further comprises eliminating edge effects constituted by imperfections having a strength depending on the limited number of polynomials.

46. A method as defined in claim 45, wherein:

eliminating the edge effects comprises defining overlapping windows;

identifying polynomials from the set to model the wanted signal components comprises identifying, in each window, polynomials from the set to model the wanted signal components;

outputting the polynomials identified as modeling the wanted signal components comprises outputting, for each window, the polynomials identified as modeling the wanted signal components to thereby produce in said window a filtered signal part; and eliminating the edge effects further comprises:

in each window, weighting the filtered signal part to suppress the filtered signal part at opposite ends of the window and emphasize the filtered signal part in the central part of said window; and

summing the weighted filtered signal parts of the overlapping windows to form an output filtered signal generally free from edge effects.

47. A method as defined in claim 46, wherein defining overlapping windows comprises:

defining 50% overlapping windows.

48. A method as defined in claim 46, wherein weighting the filtered signal part in each window comprises:

providing for each window an edge effect suppressing function; and

in each window, multiplying the filtered signal part by the edge effect suppressing function of said window.

49. A method as defined in claim 48, wherein providing for each window an edge effect suppressing function comprises:

constructing an edge effect suppressing function in such a manner that:

- a sum of the edge effect suppressing functions of the various overlapping windows is equal to unity; and
- a value of the edge suppressing function at opposite ends of each window is equal to zero.

50. A method as defined in claim 48, comprising selecting the edge effect suppressing functions of the overlapping windows from the group consisting of: a triangular function and a squared cosine function.

51. A device for filtering an input signal containing wanted signal components and unwanted signal components, comprising:

means for modeling the input signal as a set of polynomials;

means for identifying polynomials from the set to model the wanted signal components; and

means for outputting the polynomials identified as modeling the wanted signal components as an estimate of the input signal substantially free from the unwanted signal components.

52. A device as defined in claim 51, wherein the input signal modeling means comprises:

means for considering an epoch *S(t)* of the signal in a limited time interval, said epoch *S(t)* having a time scale; and

means for normalizing the time scale of the epoch *S(t)*, wherein said time scale normalizing means comprises means for shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes *S(x)*.

53. A device as defined in claim 52, wherein the input signal modeling means comprises:

means for modeling said input signal as a set of orthogonal polynomials $Q_n(x)$.

54. A device as defined in claim 53, wherein the set of orthogonal polynomials $Q_n(x)$ comprises:

a first initial polynomial $Q_0(x)$ having a constant value; and

a second initial polynomial $Q_1(x)$ having a constant slope.

55. A device as defined in claim 54, wherein input signal modeling means comprises:

means for expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \; Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x) \; Q_n(x) \; f(x) \; dx$$

where $f(x)$ is a function of x and K_n is a constant depending on the order n.

56. A device as defined in claim 55, wherein:

the input signal modeling means comprises means for modeling the input signal as a sum of a limited number of polynomials; and

said device further comprises means for eliminating edge effects constituted by imperfections having a strength depending on the limited number of polynomials.

57. A device as defined in claim 56, wherein:

the edge effects eliminating means comprises means for defining overlapping windows;

the polynomials identifying means comprises means for identifying, in each window, polynomials from the set to model the wanted signal components;

the polynomials outputting means comprises means for outputting, for each window, the polynomials identified as modeling the wanted signal components to thereby produce in said window a filtered signal part; and

the edge effects eliminating means further comprises:

for each window, means for weighting the filtered signal part to suppress the filtered signal part at opposite ends of the window and emphasize the filtered signal part in a central portion of said window; and

means for summing the weighted filtered signal parts of the overlapping windows to form an output filtered signal generally free from edge effects.

58. A device as defined in claim 57, wherein the overlapping windows comprise 50% overlapping windows.

59. A device as defined in claim 57, wherein the filtered signal part weighting means comprises:

means for providing for each window an edge effect suppressing function; and

means for multiplying, in each window, the filtered signal part by the edge effect suppressing function of said window.

60. A method of filtering an input signal containing wanted signal components and unwanted signal components, comprising:

modeling the input signal as a set of polynomials;

determining, for each polynomial, a weighting coefficient indicative of signal strength; and

summing the weighting coefficients to provide an estimate of the strength of the

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wanted signal components.

61. A method as defined in claim 60, wherein determining, for each polynomial, a weighting coefficient indicative of signal strength comprises:

modeling the strength of the wanted signal components through the weighting coefficients.

62. A method as defined in claim 60, wherein summing the weighting coefficients comprises:

summing the weighting coefficients on a square law basis with polynomial order weighting to give an estimate of a power of the wanted signal components.

63. A method as defined in claim 60, wherein summing the weighting coefficients comprises:

calculating a sum of the weighting coefficients on a square law basis with a weighting proportional to the number of oscillations for the order of the polynomial, normalized with respect to the sum of the weighting coefficients on a square law basis with polynomial order weighting, in order to obtain a dominating periodicity of the wanted signal components.

64. A method as defined in claim 60, wherein modeling the input signal as a set of polynomials comprises:

considering an epoch *S(t)* of the input signal in a limited time interval, said epoch *S(t)* having a time scale; and

normalizing the time scale of the epoch *S(t)*.

65. A method as defined in claim 64, wherein normalizing the time scale of the epoch *S(t)* comprises:

shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes *S(x)*.

66. A method as defined in claim 65, wherein modeling the input signal as a set of polynomials comprises modeling the signal as a set of orthogonal polynomials $Q_n(x)$.

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67. A method as defined in claim 66, comprising selecting the orthogonal polynomials from the group consisting of:

Legendre polynomials;

Tchebyshev T-polynomials; and

Tchebyshev U-polynomials.

68. A method as defined in claim 66, wherein modeling the input signal as a set of polynomials comprises:

expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \; Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x) \; Q_n(x) \; f(x) \; dx$$

where $f(x)$ is a function of x and K_n is a constant depending on the order n,

wherein the terms C_n constitute said weighting factors.

69. A device for filtering an input signal containing wanted signal components and unwanted signal components, comprising:

means for modeling the input signal as a set of polynomials;

means for determining, for each polynomial, a weighting factor indicative of signal strength; and

means for summing the weighting coefficients to provide an estimate of the strength of the wanted signal components.

70. A device as defined in claim 69, wherein the determining means comprises:

means for modeling the strength of the wanted signal components through the weighting coefficients.

71. A device as defined in claim 69, wherein the weighting coefficients summing means comprises:

means for summing the weighting coefficients on a square law basis with polynomial order weighting to give an estimate of a power of the wanted signal components.

72. A device as defined in claim 69, wherein the means for summing the weighting coefficients comprises:

means for calculating a sum of the weighting coefficients on a square law basis with a weighting proportional to the number of oscillations for the order of the polynomial, normalized with respect to the sum of the weighting coefficients on a square law basis with polynomial order weighting, in order to obtain a dominating periodicity of the wanted signal components.

73. A device as defined in claim 69, wherein the input signal modeling means comprises:

means for considering an epoch $S(t)$ of the input signal in a limited time interval, said epoch $S(t)$ having a time scale; and

means for normalizing the time scale of the epoch $S(t)$.

74. A device as defined in claim 73, wherein the time scale normalizing means comprises:

means for shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes $S(x)$.

75. A device as defined in claim 74, wherein the input signal modeling means comprises means for modeling the signal as a set of orthogonal polynomials $Q_n(x)$.

76. A device as defined in claim 75, wherein the input signal modeling means comprises:

means for expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \, Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x)\ Q_n(x)\ f(x)\ dx$$

where $f(x)$ is a function of x and K_n is a constant depending on the order n,

wherein the terms C_n constitute said weighting factors.

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ABSTRACT OF THE DISCLOSURE

A method and device for filtering an input signal containing wanted signal components and unwanted signal components, wherein the signal is modeled as a set of polynomials. Polynomials from the set are identified to model the unwanted signal components. These unwanted signal components are removed from the input signal by removing the polynomials identified as modeling the unwanted signal components from the set of polynomials to thereby leave in the input signal only the wanted signal components. According to an alternative, polynomials from the set are identified to model the wanted signal components, and the polynomials identified as modeling the wanted signal components are outputted as an estimate of the wanted signal components substantially free from the unwanted signal components. According to another aspect, a weighting factor indicative of signal strength is determined for each polynomial and these weighting factors are summed to provide an estimate of the strength of the input signal.

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BKP-008
(0519670.0114)

The "RECEIVED" stamp of the U.S. Patent and Trademark Office imprinted hereon acknowledges the filing of:

Transmittal Form (1 pg.); Fee Transmittal Form (1 pg.); Amendment and Response (28 pgs.); Petition for Extension of Time (1 pg.); Checks in the amount of $450.00 and 2,450.00; Certificate of First Class Mailing (1 pg.); and this return receipt postcard.

Name of Applicant:	Lindstrom
Serial Number:	10/728,081
Atty:	James E. Fajkowski
Date:	September 8, 2006

OIPE IAP69
SEP 11 2006
PATENT & TRADEMARK OFFICE

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AUG 20 2007

PATENT
Attorney Docket No. BKP-008

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT(S):	Lindstrom	CONFIRMATION NO.:	7653
SERIAL NO.:	10/728,081	GROUP NO.:	3766
FILING DATE:	December 4, 2004	EXAMINER:	Gedeon, Brian T.
TITLE:	Signal Filtering Using Orthogonal Polynomials and Removal of Edge Effects		

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT AND RESPONSE

Applicant submits this Amendment and Response in response to the non-final Office action mailed from the U.S. Patent and Trademark Office on April 11, 2006, in the above-referenced patent application.

Applicant submits a petition for a two month extension of time and the $450.00 fee with this submission. The Commissioner is hereby authorized to charge any other required fees to Deposit Account No. 50-1721.

Amendments to the claims begin on page 2 of this paper.

Remarks begin on page 23 of this paper.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in this application:

Listing of Claims

1. (Currently amended). A method of filtering an EMG input signal ~~containing wanted signal components and unwanted signal components~~ contaminated by a disturbance signal, the filtering method comprising:

modeling the ~~input signal as a set of~~ disturbance signal as polynomials of lower orders;

~~identifying polynomials from the set to model the unwanted signal components~~; and

removing the ~~unwanted signal components~~ disturbance signal ~~from the input signal~~ by removing the polynomials of lower orders ~~identified as modeling the unwanted signal components~~ from the ~~set of polynomials~~ contaminated EMG input signal to thereby ~~leave in the input signal only the wanted signal components~~ obtain an EMG input signal substantially free from the disturbance signal.

2-4. (Cancelled).

5. (Currently amended). A method ~~as defined in claim 1~~ of filtering an input signal containing wanted signal components and unwanted signal components, comprising:

modeling the input signal as a set of polynomials;

modeling the unwanted signal components with a number of polynomials from the set; and

removing the unwanted signal components from the input signal by removing the number of polynomials modeling the unwanted signal components from the set of polynomials to thereby leave in the input signal only the wanted signal components;

- wherein modeling the input signal as a set of polynomials comprises:

considering an epoch S(t) of the input signal in a limited time interval, said epoch S(t) having a time scale; and

normalizing the time scale of the epoch S(t).

6. (Original). A method as defined in claim 5, wherein normalizing the time scale of the epoch S(t) comprises:

shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes S(x).

7. (Currently amended). A method as defined in claim ~~1~~ 5, wherein modeling the input signal as a set of polynomials ~~further~~ comprises modeling the input signal as a set of orthogonal polynomials.

8. (Original). A method as defined in claim 6, wherein modeling the input signal as a set of polynomials comprises modeling the input signal as a set of orthogonal polynomials $Q_n(x)$.

9. (Original). A method as defined in claim 8, wherein the set of orthogonal polynomials $Q_n(x)$ comprises:

a first initial polynomial $Q_0(x)$ having a constant value; and

a second initial polynomial $Q_1(x)$ having a constant slope.

10. (Original). A method as defined in claim 7, comprising selecting the orthogonal polynomials from the group consisting of:

Legendre polynomials;

Tchebyshev T-polynomials; and

Tchebyshev U-polynomials.

11. (Original). A method as defined in claim 8, wherein modeling the input signal as a set of polynomials comprise:

expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \; Q_n(x)$$

where P represents a limited number of terms, and

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$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x)\ Q_n(x)\ f(x)\ dx$$

where f(x) is a function of x and K_n is a constant depending on the order n.

12. (Currently amended). A method as defined in claim 11, wherein ~~identifying polynomials from the set to model~~ modeling the unwanted signal components comprises:

associating particular orders of the polynomials with the unwanted signal components; and

modeling the unwanted signal components as a sum of the polynomials of said particular orders, comprising weighting the polynomials of said particular orders by means of the coefficients C_n.

13. (Currently amended). A method as defined in claim 12, wherein removing the number of polynomials ~~identified as~~ modeling the unwanted signal components from the set of polynomials comprises:

removing the sum of weighted polynomials from the sum of polynomials $Q_n(x)$.

14. (Currently amended). A method ~~as defined in claim 1~~ of filtering an input signal containing wanted signal components and unwanted signal components, comprising:

modeling the input signal as a set of polynomials;

modeling the unwanted signal components with a number of polynomials from the set; and

removing the unwanted signal components from the input signal by removing the number of polynomials modeling the unwanted signal components from the set of polynomials to thereby leave in the input signal only the wanted signal components;

- wherein:

modeling the input signal as a set of polynomials comprises modeling the input signal as a sum of a limited number of polynomials; and

said method further comprises eliminating edge effects constituted by imperfections having a strength depending on the limited number of polynomials.

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15. (Currently amended). A method as defined in claim 14, wherein:

eliminating the edge effects comprises defining overlapping windows;

~~identifying polynomials from the set to model~~ modeling the unwanted signal components comprises ~~identifying~~ modeling, in each window, ~~polynomials from the set to model~~ the unwanted signal components with a number of polynomials from the set;

removing the ~~unwanted signal components~~ disturbance signal from the input signal comprises removing, in each window, the number of polynomials ~~identified as~~ modeling the unwanted signal components from the set of polynomials to thereby produce in said window a filtered signal part; and

eliminating edge effects further comprises:

in each window, weighting the filtered signal part to suppress the filtered signal part at opposite ends of the window and emphasize the filtered signal part in the central portion of said window; and

summing the weighted filtered signal parts of the overlapping windows to form an output filtered signal generally free from edge effects.

16. (Original). A method as defined in claim 15, wherein defining overlapping windows comprises:

defining 50% overlapping windows.

17. (Original). A method as defined in claim 15, wherein weighting the filtered signal part in each window comprises:

providing for each window an edge effect suppressing function; and

in each window, multiplying the filtered signal part by the edge effect suppressing function of said window.

18. (Original). A method as defined in claim 17, wherein providing for each window an edge effect suppressing function comprises:

constructing an edge effect suppressing function in such a manner that:

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a sum of the edge effect suppressing functions of the various overlapping windows is equal to unity; and

a value of the edge suppressing function at opposite ends of each window is equal to zero.

19. (Original). A method as defined in claim 18, comprising selecting the edge effect suppressing functions of the overlapping windows from the group consisting of: a triangular function and a squared cosine function.

20. (Currently amended). A method ~~as defined in claim 1~~ of filtering an input signal containing wanted signal components and unwanted signal components, comprising:

modeling the input signal as a set of polynomials;

modeling the unwanted signal components with a number of polynomials from the set; and

removing the unwanted signal components from the input signal by removing the number of polynomials modeling the unwanted signal components from the set of polynomials to thereby leave in the input signal only the wanted signal components;

~~-~~ wherein modeling the input signal as a set of polynomials comprises:

using higher order polynomials that mimic an oscillatory pattern of the input signal.

21. (Currently amended). A device for filtering an EMG input signal ~~containing wanted signal components and unwanted signal components~~ contaminated by a disturbance signal, the device comprising:

means for modeling the ~~input signal as a set of~~ disturbance signal as polynomials of lower orders;

~~means for identifying polynomials from the set to model the unwanted signal components;~~ and

means for removing the ~~unwanted signal components~~ disturbance signal from the contaminated input signal, wherein the ~~unwanted signal components~~ disturbance signal removing means comprises means for removing the polynomials ~~identified as modeling the unwanted signal components~~ of lower orders from the ~~set of polynomials~~ input signal to thereby ~~leave in~~

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~~the input signal only the wanted signal components~~ obtain an EMG input signal substantially free from the disturbance signal.

22. (Currently amended). A device ~~as defined in claim 21~~ for filtering an input signal containing wanted signal components and unwanted signal components, comprising:

means for modeling the input signal as a set of polynomials;

means for modeling the unwanted signal components with a number of polynomials of said set; and

means for removing the unwanted signal components from the contaminated input signal, wherein the unwanted signal components removing means comprises means for removing the number of polynomials modeling the unwanted signal components from the set of polynomials to thereby leave in the input signal only the wanted signal components;

~~-~~ wherein the input signal modeling means comprises:

means for considering an epoch S(t) of the input signal in a limited time interval, said epoch S(t) having a time scale; and

means for normalizing the time scale of the epoch S(t), wherein said time scale normalizing means comprises means for shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes S(x).

23. (Original). A device as defined in claim 22, wherein the input signal modeling means comprises:

means for modeling the input signal as a set of orthogonal polynomials $Q_n(x)$.

24. (Original). A device as defined in claim 23, wherein the set of orthogonal polynomials $Q_n(x)$ comprises:

a first initial polynomial $Q_0(x)$ having a constant value; and

a second initial polynomial $Q_1(x)$ having a constant slope.

25. (Original). A device as defined in claim 24, wherein the input signal modeling means comprises:

means for expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \; Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x) \; Q_n(x) \; f(x) \; dx$$

where f(x) is a function of x and K_n is a constant depending on the order n.

26. (Original). A device as defined in claim 25, wherein:

the input signal modeling means comprises means for modeling the input signal as a sum of a limited number of polynomials; and

said device further comprises means for eliminating edge effects constituted by imperfections having a strength depending on the limited number of polynomials.

27. (Currently amended). A device as defined in claim 26, wherein:

the edge effects eliminating means comprises means for defining overlapping windows;

the ~~polynomials identifying means~~ <u>means for modeling the unwanted signal components</u> comprises means for ~~identifying~~ <u>modeling</u>, in each window, ~~polynomials from the set to model~~ the unwanted signal components <u>with a number of polynomials of said set</u>;

the unwanted signal components removing means comprises means for removing, in each window, the <u>number of</u> polynomials ~~identified as~~ modeling the unwanted signal components from the set of polynomials to thereby produce in said window a filtered signal part; and

the edge effects eliminating means further comprises:

for each window, means for weighting the filtered signal part to suppress the filtered signal part at opposite ends of the window and emphasize the filtered signal part in the central portion of said window; and

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means for summing the weighted filtered signal parts of the overlapping windows to form an output filtered signal generally free from edge effects.

28. (Original). A device as defined in claim 27, wherein the overlapping windows comprise 50% overlapping windows.

29. (Original). A device as defined in claim 27, wherein the filtered signal part weighting means comprises:

means for providing for each window an edge effect suppressing function; and

means for multiplying, in each window, the filtered signal part by the edge effect suppressing function of said window.

30. (Currently amended). A method of filtering an EMG input signal ~~containing wanted signal components and unwanted signal components~~ contaminated by a disturbance signal, the filtering method comprising:

modeling the EMG input signal as ~~a set of~~ polynomials of higher orders;

~~identifying polynomials from the set to model the wanted signal components;~~ and

outputting the polynomials ~~identified as modeling the wanted signal components~~ of higher orders as an estimate of the EMG input signal substantially free from the ~~unwanted signal components~~ disturbance signal.

31. (Currently amended). A method as defined in claim 30, wherein the ~~wanted signal components comprise a myoelectric signal and the unwanted signal components comprise~~ disturbance signal comprises at least one of a cardiac signal, motion disturbance, and background noise.

32.-33. (Cancelled).

34. (Currently amended). A method ~~as defined in claim 30~~ of filtering an input signal containing wanted signal components and unwanted signal components, comprising:

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modeling the input signal as a set of polynomials;

modeling the wanted signal components with a number of the polynomials of said set; and

outputting the polynomials modeling the wanted signal components as an estimate of the input signal substantially free from the unwanted signal components;

- wherein modeling the input signal comprises:

considering an epoch S(t) of the signal in a limited time interval, said epoch S(t) having a time scale; and

normalizing the time scale of the epoch S(t).

35. (Original). A method as defined in claim 34, wherein normalizing the time scale of the epoch S(t) comprises:

shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes S(x).

36. (Currently amended). A method as defined in claim 30, wherein modeling the EMG input signal as ~~a set of~~ polynomials of higher orders comprises modeling said EMG input signal as ~~a set of~~ orthogonal polynomials of higher orders.

37. (Original). A method as defined in claim 35, wherein modeling the input signal as a set of polynomials comprises modeling the input signal as a set of orthogonal polynomials $Q_n(x)$.

38. (Original). A method as defined in claim 37, wherein the set of orthogonal polynomials $Q_n(x)$ comprises:

a first initial polynomial $Q_0(x)$ having a constant value; and

a second initial polynomial $Q_1(x)$ having a constant slope.

39. (Original). A method as defined in claim 36, comprising selecting the orthogonal polynomials from the group consisting of:

Legendre polynomials;

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Tchebyshev T-polynomials; and

Tchebyshev U-polynomials.

40. (Original). A method as defined in claim 37, wherein modeling the input signal as a set of polynomials comprises:

expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \; Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x) \; Q_n(x) \; f(x) \; dx$$

where f(x) is a function of x and K_n is a constant depending on the order n.

41. (Cancelled).

42. (Currently amended). A method as defined in claim 30, further comprising weighting the polynomials ~~identified as~~ modeling the ~~wanted signal components~~ <u>the EMG input signal</u> by means of weighting coefficients.

43. (Currently amended). A method as defined in claim 40, wherein ~~identifying polynomials from the set to model the wanted signal components~~ <u>modeling the wanted signal components with a number of the polynomials of said set</u> comprises:

associating particular orders of the polynomials with the wanted signal components; and

modeling the wanted signal components as a sum of the polynomials of said particular orders, comprising weighting the polynomials of said particular orders by means of the coefficients C_n.

44. (Currently amended). A method ~~as defined in claim 30~~ <u>of filtering an input signal containing wanted signal components and unwanted signal components, comprising:</u>

<u>modeling the input signal as a set of polynomials;</u>

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modeling the wanted signal components with a number of the polynomials of said set; and

outputting the polynomials modeling the wanted signal components as an estimate of the input signal substantially free from the unwanted signal components;

- wherein modeling the input signal as a set of polynomials comprises:

using higher order polynomials that mimic an oscillatory pattern of the input signal.

45. (Currently amended). A method ~~as defined in claim 30~~ of filtering an input signal containing wanted signal components and unwanted signal components, comprising:

modeling the input signal as a set of polynomials;

modeling the wanted signal components with a number of the polynomials of said set; and

outputting the number of polynomials modeling the wanted signal components as an estimate of the input signal substantially free from the unwanted signal components;

- wherein:

modeling the input signal as a set of polynomials comprises modeling the input signal as a sum of a limited number of polynomials; and

said method further comprises eliminating edge effects constituted by imperfections having a strength depending on the limited number of polynomials.

46. (Currently amended). A method as defined in claim 45, wherein:

eliminating the edge effects comprises defining overlapping windows;

~~identifying polynomials from the set to model~~ modeling the wanted signal components comprises ~~identifying~~ modeling, in each window, ~~polynomials from the set to model~~ the wanted signal components with a number of polynomials of said set;

outputting the number of polynomials ~~identified as~~ modeling the wanted signal components comprises outputting, for each window, the number of polynomials ~~identified as~~ modeling the wanted signal components to thereby produce in said window a filtered signal part; and

eliminating the edge effects further comprises:

in each window, weighting the filtered signal part to suppress the filtered signal part at opposite ends of the window and emphasize the filtered signal part in the central part of said window; and

summing the weighted filtered signal parts of the overlapping windows to form an output filtered signal generally free from edge effects.

47. (Original). A method as defined in claim 46, wherein defining overlapping windows comprises:

defining 50% overlapping windows.

48. (Original). A method as defined in claim 46, wherein weighting the filtered signal part in each window comprises:

providing for each window an edge effect suppressing function; and

in each window, multiplying the filtered signal part by the edge effect suppressing function of said window.

49. (Original). A method as defined in claim 48, wherein providing for each window an edge effect suppressing function comprises:

constructing an edge effect suppressing function in such a manner that:

a sum of the edge effect suppressing functions of the various overlapping windows is equal to unity; and

a value of the edge suppressing function at opposite ends of each window is equal to zero.

50. (Original). A method as defined in claim 48, comprising selecting the edge effect suppressing functions of the overlapping windows from the group consisting of: a triangular function and a squared cosine function.

51. (Currently amended). A device for filtering an EMG input signal ~~containing wanted signal components and unwanted signal components~~ contaminated by a disturbance signal, the device comprising:

means for modeling the EMG input signal as ~~a set of~~ polynomials of higher orders;

~~means for identifying polynomials from the set to model the wanted signal components;~~ and

means for outputting the polynomials ~~identified as modeling the wanted signal components~~ of higher orders as an estimate of the EMG input signal substantially free from the ~~unwanted signal components~~ disturbance signal.

52. (Currently Amended). A device ~~as defined in claim 30~~ for filtering an input signal containing wanted signal components and unwanted signal components, comprising:

means for modeling the input signal as a set of polynomials;

means for modeling the wanted signal components with a number of the polynomials of said set; and

means for outputting the polynomials modeling the wanted signal components as an estimate of the input signal substantially free from the unwanted signal components;

~~-~~ wherein the input signal modeling means comprises:

means for considering an epoch S(t) of the signal in a limited time interval, said epoch S(t) having a time scale; and

means for normalizing the time scale of the epoch S(t), wherein said time scale normalizing means comprises means for shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes S(x).

53. (Original). A device as defined in claim 52, wherein the input signal modeling means comprises:

means for modeling said input signal as a set of orthogonal polynomials $Q_n(x)$.

54. (Original). A device as defined in claim 53, wherein the set of orthogonal polynomials $Q_n(x)$ comprises:

a first initial polynomial $Q_0(x)$ having a constant value; and

a second initial polynomial $Q_1(x)$ having a constant slope.

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55. (Currently amended). A device as defined in claim 54, wherein the input signal modeling means comprises:

means for expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \ Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x) \ Q_n(x) \ f(x) \ dx$$

where f(x) is a function of x and K_n is a constant depending on the order n.

56. (Original). A device as defined in claim 55, wherein:

the input signal modeling means comprises means for modeling the input signal as a sum of a limited number of polynomials; and

said device further comprises means for eliminating edge effects constituted by imperfections having a strength depending on the limited number of polynomials.

57. (Currently amended). A device as defined in claim 56, wherein:

the edge effects eliminating means comprises means for defining overlapping windows;

the ~~polynomials identifying~~ means for modeling the wanted signal components comprises means for ~~identifying~~ modeling, in each window, ~~polynomials from the set to model~~ the wanted signal components with a number of the polynomials of said set;

the polynomials outputting means comprises means for outputting, for each window, the polynomials ~~identified as~~ modeling the wanted signal components to thereby produce in said window a filtered signal part; and

the edge effects eliminating means further comprises:

for each window, means for weighting the filtered signal part to suppress the filtered signal part at opposite ends of the window and emphasize the filtered signal part in a central portion of said window; and

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means for summing the weighted filtered signal parts of the overlapping windows to form an output filtered signal generally free from edge effects.

58. (Original). A device as defined in claim 57, wherein the overlapping windows comprise 50% overlapping windows.

59. (Original). A device as defined in claim 57, wherein the filtered signal part weighting means comprises:

means for providing for each window an edge effect suppressing function; and

means for multiplying, in each window, the filtered signal part by the edge effect suppressing function of said window.

60. (Currently amended). A method of filtering an input signal containing wanted signal components and unwanted signal components, comprising:

modeling the input signal as a set of polynomials;

determining, for each polynomial, a weighting coefficient indicative of signal strength; and

summing the weighting coefficients to provide an estimate of the strength of the wanted signal components;

- wherein summing the weighting coefficients comprises:

summing the weighting coefficients on a square law basis with polynomial order weighting to give an estimate of a power of the wanted signal components.

61. (Original). A method as defined in claim 60, wherein determining, for each polynomial, a weighting coefficient indicative of signal strength comprises:

modeling the strength of the wanted signal components through the weighting coefficients.

62. (Cancelled).

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63. (Currently amended). A method ~~as defined in claim 60~~ of filtering an input signal containing wanted signal components and unwanted signal components, comprising:

modeling the input signal as a set of polynomials;

determining, for each polynomial, a weighting coefficient indicative of signal strength; and

summing the weighting coefficients to provide an estimate of the strength of the wanted signal components;

- wherein summing the weighting coefficients comprises:

calculating a sum of the weighting coefficients on a square law basis with a weighting proportional to the number of oscillations for the order of the polynomial, normalized with respect to the sum of the weighting coefficients on a square law basis with polynomial order weighting, in order to obtain a dominating periodicity of the wanted signal components.

64. (Currently amended). A method ~~as defined in claim 60~~ of filtering an input signal containing wanted signal components and unwanted signal components, comprising:

modeling the input signal as a set of polynomials;

determining, for each polynomial, a weighting coefficient indicative of signal strength; and

summing the weighting coefficients to provide an estimate of the strength of the wanted signal components;

- wherein modeling the input signal as a set of polynomials comprises:

considering an epoch S(t) of the input signal in a limited time interval, said epoch S(t) having a time scale; and

normalizing the time scale of the epoch S(t).

65. (Original). A method as defined in claim 64, wherein normalizing the time scale of the epoch S(t) comprises:

shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes S(x).

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66. (Original). A method as defined in claim 65, wherein modeling the input signal as a set of polynomials comprises modeling the signal as a set of orthogonal polynomials $Q_n(x)$.

67. (Original). A method as defined in claim 66, comprising selecting the orthogonal polynomials from the group consisting of:

Legendre polynomials;

Tchebyshev T-polynomials; and

Tchebyshev U-polynomials.

68. (Original). A method as defined in claim 66, wherein modeling the input signal as a set of polynomials comprises:

expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \; Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x) \; Q_n(x) \; f(x) \; dx$$

where f(x) is a function of x and K_n is a constant depending on the order n, wherein the terms C_n constitute said weighting factors.

69. (Currently amended). A device for filtering an input signal containing wanted signal components and unwanted signal components, comprising:

means for modeling the input signal as a set of polynomials;

means for determining, for each polynomial, a weighting factor indicative of signal strength; and

means for summing the weighting coefficients to provide an estimate of the strength of the wanted signal components;

<u>- wherein the weighting coefficients summing means comprises:</u>

means for summing the weighting coefficients on a square law basis with polynomial order weighting to give an estimate of a power of the EMG input signal substantially free from the disturbance signal.

70. (Original). A device as defined in claim 69, wherein the determining means comprises:

means for modeling the strength of the wanted signal components through the weighting coefficients.

71. (Cancelled).

72. (Currently amended). A device ~~as defined in claim 69~~ for filtering an input signal containing wanted signal components and unwanted signal components, comprising:

means for modeling the input signal as a set of polynomials;

means for determining, for each polynomial, a weighting factor indicative of signal strength; and

means for summing the weighting coefficients to provide an estimate of the strength of the wanted signal components;

- wherein the means for summing the weighting coefficients comprises:

means for calculating a sum of the weighting coefficients on a square law basis with a weighting proportional to the number of oscillations for the order of the polynomial, normalized with respect to the sum of the weighting coefficients on a square law basis with polynomial order weighting, in order to obtain a dominating periodicity of the ~~wanted signal components~~ input signal.

73. (Currently amended). A device ~~as defined in claim 69~~ for filtering an input signal containing wanted signal components and unwanted signal components, comprising:

means for modeling the input signal as a set of polynomials;

means for determining, for each polynomial, a weighting factor indicative of signal strength; and

means for summing the weighting coefficients to provide an estimate of the strength of the wanted signal components;

- wherein the input signal modeling means comprises:

means for considering an epoch S(t) of the input signal in a limited time interval, said epoch S(t) having a time scale; and

means for normalizing the time scale of the epoch S(t).

74. (Original). A device as defined in claim 73, wherein the time scale normalizing means comprises:

means for shifting and scaling the limited time interval under consideration into a new variable x in an interval $-1<x<1$ whereby the signal epoch becomes S(x).

75. (Original). A device as defined in claim 74, wherein the input signal modeling means comprises means for modeling the signal as a set of orthogonal polynomials $Q_n(x)$.

76. (Original). A device as defined in claim 75, wherein the input signal modeling means comprises:

means for expressing the input signal as a sum of the polynomials $Q_n(x)$:

$$S(x)=\sum_{n=0}^{P} C_n \; Q_n(x)$$

where P represents a limited number of terms, and

$$C_n = \frac{1}{K_n} \int_{-1}^{+1} S(x) \; Q_n(x) \; f(x) \; dx$$

where f(x) is a function of x and K_n is a constant depending on the order n, wherein the terms C_n constitute said weighting factors.

77. (New). A method of filtering as defined in claim 1, wherein the disturbance signal comprises at least one signal selected from the group consisting of: ECG signals, movement induced disturbances, and background noise.

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78. (New). A method of filtering as defined in claim 1, wherein polynomials of lower orders comprise Legendre polynomials of orders from zero (0) to seven (7).

79. (New). A method of filtering as defined in claim 1, wherein the polynomials of lower orders comprise at least one of Tchebychev T-polynomials and Tchebychev U-polynomials.

80. (New) A method of filtering as defined in claim 1, further comprising modeling the contaminated EMG input signal as a set of polynomials and wherein removing the disturbance signal comprises removing the polynomials of lower orders from the set of polynomials modeling the contaminated EMG input signal to thereby obtain an EMG input signal substantially free from the disturbance signal.

81. (New). A device as defined in claim 21, wherein the disturbance signal comprises at least one signal selected from the group consisting of: ECG signals, movement induced disturbances and background noise.

82. (New). A device as defined in claim 21, wherein the polynomials of lower orders comprise Legendre polynomials of orders from zero (0) to seven (7).

83. (New). A device as defined in claim 21, wherein the polynomials of lower orders comprise at least one of Tchebychev T-polynomials and Tchebychev U-polynomials.

84. (New) A device as defined in claim 21, further comprising means for modeling the contaminated EMG input signal as a set of polynomials and wherein the means for removing the disturbance signal comprises means for removing the polynomials of lower orders from the set of polynomials modeling the contaminated EMG input signal to thereby obtain an EMG input signal substantially free from the disturbance signal.

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85. (New). A method of filtering as defined in claim 30, wherein the disturbance signal comprises at least one signal selected from the group consisting of: ECG signals, movement induced disturbances and background noise.

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REMARKS/ARGUMENTS

The present amendment and response is filed in response to the Office Action mailed April 11, 2006. In the present amendment, claims 2-4, 32, 33, 41, 62 and 71 have been cancelled without prejudice, claims 77-85 are newly submitted, and claims 1, 5, 7, 12-15, 20-22, 27, 30, 31, 34, 36, 42-46, 51, 52, 55, 57, 60, 63, 64, 69, 72 and 73 have been amended

Claim Rejections – 35 USC § § 102 & 103.

In the outstanding Office Action:

1. Claims 1, 21, 30, 41-43 and 51 are rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Lyon (US Patent No. 5,502,663);

2. Claims 2 and 31 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon (US Patent No. 5,502,663) in view of Kynor et al. (US Patent No. 5,603,321);

3. Claims 3; 4, 32 and 33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon (US Patent No. 5,502,663) in view of Arand et al. (US Patent No. 5,318,036);

4. Claims 7 and 36 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon (US Patent No. 5,502,663) in view of Levine (US Patent No. 5,579,243);

5. Claims 10 and 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon (US Patent No. 5,502,663) in view of Levine (US Patent No. 5,579,243) and further in view of Kouri et al. (US Patent No. 6,847,737); and

6. Claims 60, 61, 69 and 70 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon (US Patent No. 5,502,663) in view of Corless et al. (US Patent No. 6,988,116).

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In order to overcome the above rejections of the independent claims have been amended to read as follows:

1. *A method of filtering an EMG input signal contaminated by a disturbance signal, the filtering method comprising:*

modeling the disturbance signal as polynomials of lower orders; and

removing the disturbance signal by removing the polynomials of lower orders from the contaminated EMG input signal to thereby obtain an EMG input signal substantially free from the disturbance signal.

21. *A device for filtering an EMG input signal contaminated by a disturbance signal, comprising:*

means for modeling the disturbance signal as polynomials of lower orders; and

means for removing the disturbance signal from the contaminated input signal, wherein the disturbance signal removing means comprises means for removing the polynomials of lower orders from the input signal to thereby obtain an EMG input signal substantially free from the disturbance signal.

30. *A method of filtering an EMG input signal contaminated by a disturbance signal, the filtering method comprising:*

modeling the EMG input signal by polynomials of higher orders; and

outputting the polynomials of higher orders as an estimate of the EMG input signal substantially free from the disturbance signal.

51. *A device for filtering an EMG input signal contaminated by a disturbance signal, comprising:*

means for modeling the EMG input signal as polynomials of higher orders; and

means for outputting the polynomials of higher orders as an estimate of the input signal substantially free from the disturbance signal.

The subject matter of amended independent claims 1, 21, 30 and 51 is supported by the description. More specifically, the subject matter of amended independent claims 1 and 21 is disclosed in page 10, lines 27-32 and in page 19, lines 11-14. In the same manner, the subject matter of independent claims 30 and 51 is disclosed in page 10, lines 27-32 and in page 19, lines 11-14. Since page 19, lines 11-14 indicates that the unwanted signal components are synthesized from Legendre polynomials of orders zero (0) to seven (7) (lower order polynomials), it is obvious that the wanted signal components will be represented by the other Legendre polynomials (higher order polynomials).

It is respectfully submitted that amended independent claims 1 and 21 are allowable at least for the reason that the references cited by the Examiner, taken separately or in combination, fail to teach about modeling a disturbance signal as polynomials of lower orders and removing the disturbance signal by removing the polynomials of lower orders from the contaminated EMG input signal to thereby obtain an EMG input signal substantially free from the disturbance signal.

The first reference, Lyon (US Patent No. 5,502,663), discloses a filter that may include different damping and frequency cut-off parameters. Polynomials are used to approximate the coefficients of the filter, for easier computation purposes. Therefore, Lyon fails to describe of suggest that a disturbance signal can be modeled as polynomials, more specifically lower-order polynomials, for removal from an EMG input signal.

The second reference, Kynor et al. (US Patent No. 5,603,321), discloses a method of removing background noise from cardiac signals by using times-series isoelectric artifacts. It is respectfully submitted that Kynor et al., fail to describe or suggest that a disturbance signal can be modeled as polynomials, more specifically lower-order polynomials, for removal from an EMG input signal.

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The third reference, Arand et al. (US Patent No. 5,318,036), uses IIR filters to remove baseline wander from ECG signals. Although Arand et al., describes the use of the cubic spline method, in which the baseline wander is estimated with a third order polynomial and the estimate is subtracted from the ECG signal, Arand et al., still fails to describe or suggest modeling of a disturbance signal as polynomials of lower orders for removal from an EMG input signal.

The fourth reference, Levine (US Patent No. 5,579,243), discloses a filter synthesizer that generates orthogonal polynomial data from a cost function, corresponding to Forsythe polynomials. Although Levine discloses a method of generating polynomials, Levine fails to disclose modeling a disturbance signal as polynomials of lower orders for removal of this disturbance signal from an EMG input signal.

The fifth reference, Kouri et al. (US Patent No. 6,847,737), teaches about a method for padding, filtering, denoising and image enhancing digitized data. Their approach allows for generating a set of polynomials which are orthonormal. Classical polynomial systems such as Chebychev and Legendre are special cases of this approach. However, there is no disclosure of modeling a disturbance signals as polynomials, more specifically lower-order polynomials, for removal from an EMG input signal.

The sixth reference, Corless et al. (US Patent No. 6,988,116) describes a filtering method using cascades of first or second order filters, whose coefficients are calculated by using second order polynomials with respect to some characteristics corresponding to different cut-off frequencies. The polynomials are used to calculate the coefficients of the filter, they are not used to model a disturbance signal (with lower-order polynomials) for the purpose of removing this disturbance signal from an EMG signal.

In view of the above comments, it is respectfully submitted that none of the cited references, taken separately or in combination, discloses the subject matter of amended independent claims 1 and 21. Therefore, newly submitted independent claims 1 and 21 are believed to be allowable as well as the dependent claims directly or indirectly dependent thereon.

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Concerning the amended independent claims 30 and 51, the same comments as above apply, since none of the cited references discloses modeling a disturbance-free EMG signal as polynomials, more specifically higher-order polynomials. More specifically, it is respectfully submitted that amended independent claims 30 and 51 are allowable as well as the dependent claims directly or indirectly dependent thereon, since none of the references cited by the Examiner, taken separately or in combination, teaches about modeling an EMG signal as polynomials of higher orders and outputting the polynomials of higher orders as an estimate of the EMG input signal substantially free from a disturbance signal.

Allowable subject matter

In the Office Action of April 11, 2006 claims 5, 6, 8, 9, 11-20, 22-29, 34, 35, 37, 38, 40, 44-50, 52-59, 62-68 and 71-76 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Accordingly, claims 5, 14, 20, 22, 34, 44, 45, 52, 63, 64, 72 and 73 have been drafted into independent form including substantially all the limitations of the base claims and any intervening claims, the subject matter of claim 62 has been introduced in claim 60 and the subject matter of claim 71 has been inserted in claim 69 to render these claims and the claims dependent thereon allowable.

CONCLUSION

In view of the foregoing arguments, Applicants respectfully request reconsideration, withdrawal of all grounds of rejection, and allowance of claims 1, 5-31, 34-40, 42-61, 63-70 and 72-85 in due course. The Examiner is invited to contact Applicants' undersigned representative by telephone at the number listed below to discuss any outstanding issues.

In light of the foregoing, we submit that all claims are now in condition for allowance.

Respectfully submitted,

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BOS-1003364 v2